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# EFFECTS OF PRECISION DEMAND AND MENTAL PRESSURE IN AIMING AND TRACKING TASKS

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**Abstract** - The objective of the present study was to gain insight into the effects of precision demands and mental pressure on the applied grip and click forces on the computer mouse. We used two computer mouse tasks: an aiming and a tracking task. Performance measures indicated that the levels of the independent variables resulted in distinguishable levels of accuracy and tempo. Precision demands had no effect on the applied grip and click forces on the computer mouse, but large effects on performance. Mental pressure had an almost significant effect on the applied grip force during tracking and substantial effects on the applied grip and click forces during aiming, with grip and click forces increasing by 51% and 40% respectively. Mental pressure had small effects on accuracy but large effects on tempo during aiming.

## INTRODUCTION

There are indications that UEMSDs are related to computer work (Fogleman and Brogmus 1995, Karlqvist et al. 1996, Punnett and Bergqvist 1997, Jensen et al. 2002). In a few studies mouse use is indicated as a risk factor in computer work (Karlqvist et al. 1996, Jensen et al. 1998, Jensen et al. 2002).

Computer work often comprises high precision and concentration demands and high time pressure. The aim of the present study was to gain insight into the effects of precision demands and mental pressure (to perform accurately and to perform at highest speed) on the load of the upper extremity. Several combinations of precision demands and mental pressure were imposed in two computer mouse tasks: an aiming and a tracking task. The upper extremity load was operationalized as the grip and click forces applied on the computer mouse.

To check whether levels of the independent variables were chosen such that the subjects' effort was indeed affected systematically, the effects of precision demands and mental pressure on task performance were studied as well.

## METHODS

Ten healthy subjects (4 males, 6 females; age 23-58 years) participated in the study. They had experience in computer work, but were no professional computer workers.

The subjects performed two computer mouse tasks: a tracking task and an aiming task. Each task was performed

at two levels of precision and two levels of mental pressure.

In the tracking task subjects made the cursor follow a dot moving on the computer screen in a circle at a fixed speed. The level of precision was set by the diameter of the dot. Mental pressure was increased in the high pressure condition by a verbal instruction to perform as good as possible in combination with performance feedback. The task comprised of twelve rounds with a duration of 15 seconds each (total 120 seconds).

In the aiming task subjects were asked to click on a dot, which appeared at random locations on the computer screen. The level of precision was defined by the diameter of the dot. In the low mental pressure condition, 60 dots were presented on the screen with an interval of two seconds between the dots (total 120 seconds). In the high mental pressure condition the subjects had to make 60 correct clicks as quickly as possible. A penalty of two extra dots was given for each miss.

To exclude order effects, the various precision and mental pressure conditions were presented in a balanced design.

The computer mouse was equipped with two force transducers, a click-force and a grip-force transducer. The click-force transducer was placed internally in the mouse under the left mouse button. This transducer measures the contact force of the index finger on the left mouse button.

The mouse further includes a force transducer on the left-hand side to measure the grip force of the user's thumb on the device. The sample frequency was 20 (Hz).

The mean grip-force was calculated for both tasks, and the mean click-force was calculated for the aiming task.

The position (XY-coördinates) of the centre of the target dot and the position of the cursor were recorded. During the tracking tasks a sample frequency of 50 (Hz) was used, during the aiming tasks the positions were recorded at each mouse click.

Two performance measures were calculated for the tracking tasks: Distance - The mean distance (pixels) between the cursor and the middle of the target dot; and %Missing - The percentage of the time the cursor was not

positioned on the target dot.

Three performance measures were calculated for the aiming tasks: Distance - The mean distance (pixels) between the cursor and the middle of the target dot at the moment of clicking; Missed - The number of missed dots till 60 correct clicks were made; and Time/click - The time per click, calculated over the first 60 clicks.

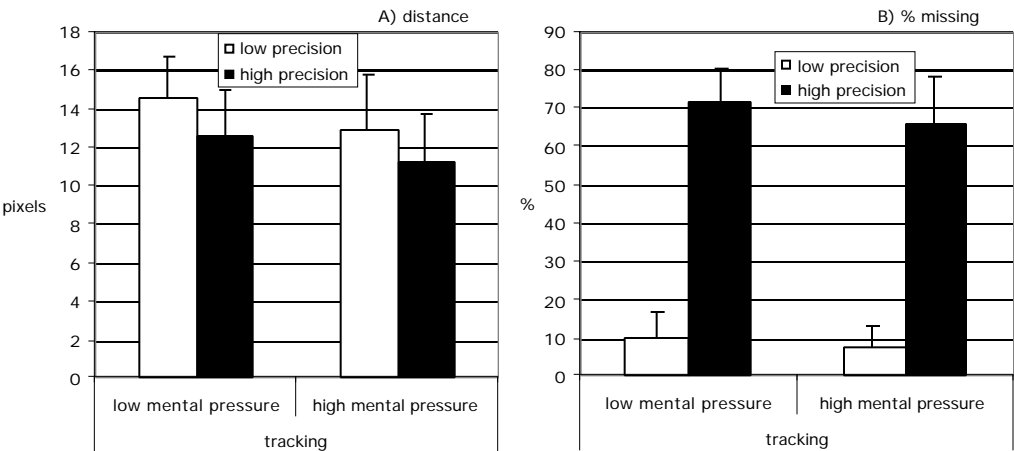


figure 1 Mean and standard deviation (error bars) of the performance measures for the tracking tasks at 2 levels of precision demand and 2 levels of mental pressure. a) Distance, the mean distance (pixels) between the cursor and the middle of the target dot. b) %Missing, the percentage of the time the cursor was not positioned on the target dot.

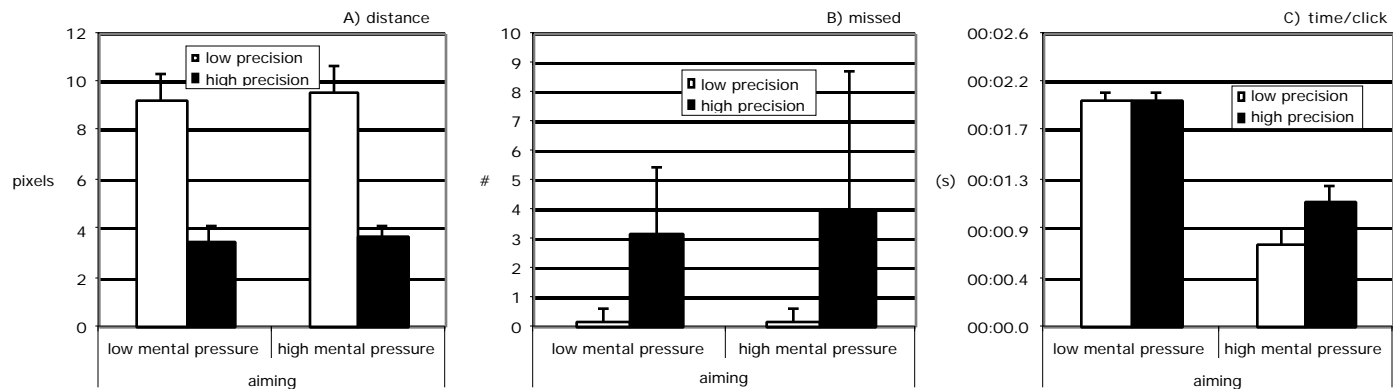


figure 2 Mean and standard deviation (error bars) of the performance measures for the aiming tasks at 2 levels of precision demand and 2 levels of mental pressure. a) Distance, the mean distance (pixels) between the cursor and the middle of the target dot at the moment of clicking. b) Missed, the number of missed dots till 60 correct clicks were made. c) Time/click, the time per click (s), calculated over the first 60 clicks.

## RESULTS

The performance results for the tracking tasks are presented in figures 1a-b. Precision demands ( $F=17.48$ ,  $P=0.002$ ) and mental pressure ( $F=22.186$ ,  $P=0.001$ ) both had a significant effect on the mean distance between the cursor and the middle of the target dot (see figure 1a). High

precision demands and high mental pressure led to smaller distances between cursor and the middle of the target dot.

Precision demands ( $F=807.977$ ,  $P=0.000$ ) and mental pressure ( $F=12.383$ ,  $P=0.006$ ) also had a significant effect on the percentage of the time the cursor was not positioned on the target dot (see figure 1b).

The high precision level led to high percentages of the

time the cursor was not on the dot. The effect of mental pressure was much smaller and opposite in direction, under high pressure the cursor was on the dot a higher percentage of time.

There were no significant interaction effects of precision demands and mental pressure on 'Distance' ( $F=0.144$ ,  $P=0.712$ ) and '% Missing' ( $F=2.238$ ,  $P=0.166$ ).

The performance measures for the aiming tasks are presented in figures 2a-c. Precision demands had a marked effect on the three performance measures. High precision demands led to a) smaller distances between the cursor and the middle of the target dot at the moment of clicking ( $F=678.667$ ,  $P=0.000$ ), b) more missed dots till 60 correct clicks were given ( $F=11.769$ ,  $P=0.008$ ) and c) an increase in time per click, calculated over the first 60 clicks ( $F=252.525$ ,  $P=0.000$ ).

Mental pressure only had a significant effect on 'time/click' ( $F=1089.814$ ,  $P=0.000$ ). High mental pressure led to a decreased 'time/click'.

A significant interaction effect was present of precision demand and mental pressure on the 'time/click' ( $F=261.778$ ,  $P=0.000$ ), with 'time/click' being dependent on precision in the high mental pressure condition but not in the low mental pressure condition.

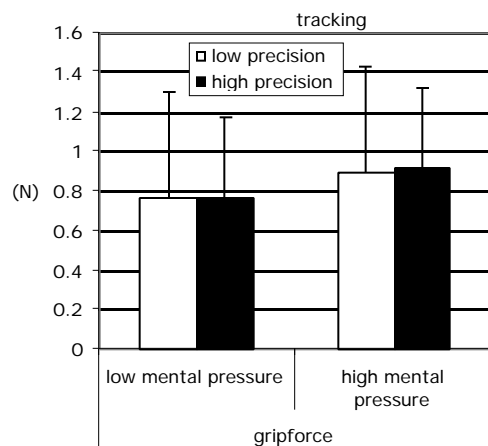


figure 3 Mean and standard deviation (error bars) of the grip force (N) during tracking at 2 levels of precision demand and 2 levels of mental pressure.

Results of the grip force applied to the mouse during the tracking tasks are presented in figure 3. No significant effects of precision ( $F=0.061$ ,  $P=0.811$ ) were found for the grip force applied to the mouse. The influence of mental pressure on grip force ( $F=4.863$ ,  $P=0.055$ ) was almost significant.

Results of the grip force and click force applied to the mouse during the aiming tasks are presented in figures 4. No significant effects of precision were found for the grip force

( $F=0.188$ ,  $P=0.675$ ) and click force ( $F=0.132$ ,  $P=0.725$ ) applied to the mouse. Mental pressure had a significant effect on the grip ( $F=7.394$ ,  $P=0.024$ ) and click force ( $F=30.005$ ,  $P=0.000$ ), with higher mental pressure resulting in higher forces applied to the mouse. Increases in grip force and click force were 51% and 40% respectively.

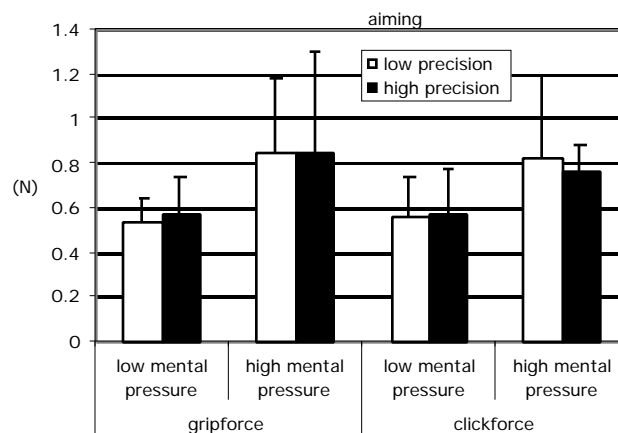


figure 4 Mean and standard deviation (error bars) of the grip force (N) and click force (N) during aiming at 2 levels of precision demand and 2 levels of mental pressure.

## DISCUSSION

The goal of this study was to simulate work situations with different levels of mental pressure and precision demand. Both factors of interest were defined in terms of demands to perform at a certain level with respect to accuracy and/or speed. Thus, performance measures could be used to check whether the manipulations were effective in this regard. There were clear effects of precision demands in both mouse tasks on all performance measures. Mental pressure effects were smaller but nevertheless present in both tasks. We may therefore conclude that the levels of the independent variables imposed differed sufficiently to simulate work situations with distinguishable levels of precision and mental pressure. The absence of significant interaction effects of precision and mental pressure for four of the five performance measures indicates that their effects were additive and not multiplicative. The interaction effect found on the 'time/click' in the aiming task was due to the fact that the dots were presented at fixed intervals during the low mental pressure condition, whereas in the high mental pressure condition subjects performed as fast as possible.

No significant effects of precision on the applied grip and click forces on the computer mouse were found in spite of the clear effects on performance in both tasks. In other words, the increased effort, necessary to achieve the

precision demands is not reflected in changes in the applied grip and click forces on the computer mouse. Effects of precision may have been counterbalanced by a lower productivity. This was illustrated by Birch et al. (2000), who investigated simulated computer work with different levels of precision, time pressure, and mental demand. They found that high precision demands and high mental demands did not influence the EMG of upper extremity musculature. However, productivity appeared reduced. It should be noted that in the present study productivity under high precision demand was at least equal to the reference condition, except in the aiming task under high mental pressure. In the latter condition, the productivity (time/click) decreased. In working life similar effects may occur and this may reduce effects of precision demands on physical loading.

There was an effect of mental pressure on the grip and click force, with higher mental pressure resulting in higher forces applied to the mouse. The stronger effect in the aiming task may be explained on the basis of differences in movement speed, which was intentionally influenced. The higher grip forces may be related to the associated accelerations and decelerations. However, the increased click force during aiming would not contribute to counteracting neuromotor noise effects. This finding therefore suggests that an overall increase in arousal (Westgaard 1996, Lundberg 2002) due to the mental effort to perform as good as possible is operative as well.

Previous studies have also shown effects of work pressure on upper extremity load (Waersted 2000, Bansevicius et al. 2001, Lundberg 2002). It should be noted that a wide range of stressors, some related to the actual task and other additional to the task were used in these studies.

When comparing the effects of precision and mental pressure it can be concluded that precision had a much larger effect than mental pressure on performance and mental pressure had a larger effect than precision on the applied grip and click forces on the computer mouse.

The strong effect of precision on the performance measures might have some implications for real computer work, in such a way that making errors might have serious consequences and thereby pose high mental pressure on the worker. Feedback of the performance in the tracking task in the present study with no other consequence than getting a low end score was already enough to add mental pressure. It can be argued that in working conditions where performance is important or even crucial, precision has an indirect effect on upper extremity loading by its strong effect on performance and thereby on mental pressure. In other words, precision demands in real work can be implicit mental stressors.

## CONCLUSION

Mental pressure did, and precision did not significantly, influence the applied grip and click forces on the computer mouse. Precision and mental pressure were found to have effects on performance, with precision effects being larger than mental pressure.

## ACKNOWLEDGEMENTS

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